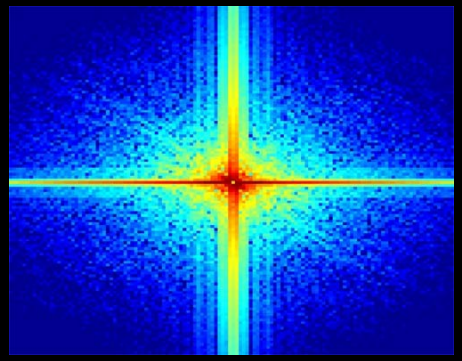
Spectral Processing of Point-Sampled Geometry



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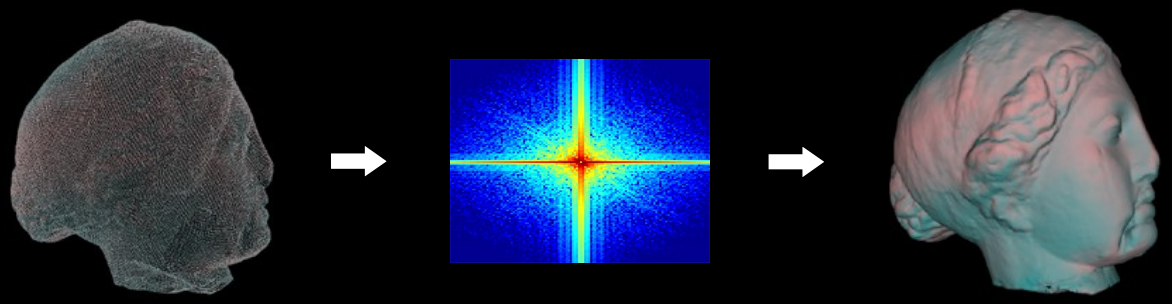
SIGGRAPH 2001 EXPLORE INTERACTION AND DIGITAL IMAGES

Outline

- Introduction
- Spectral processing pipeline
- Results
- Conclusions

Introduction

- Extend Fourier transform to 2-manifold surfaces



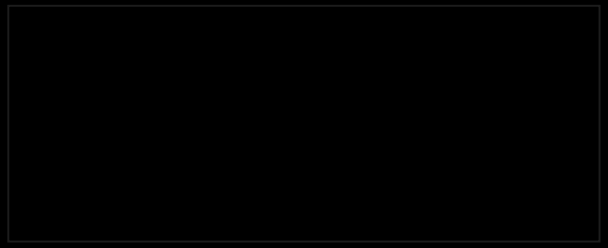
⇨ Spectral representation of point-based objects

⇨ Powerful methods for digital geometry processing

Applications

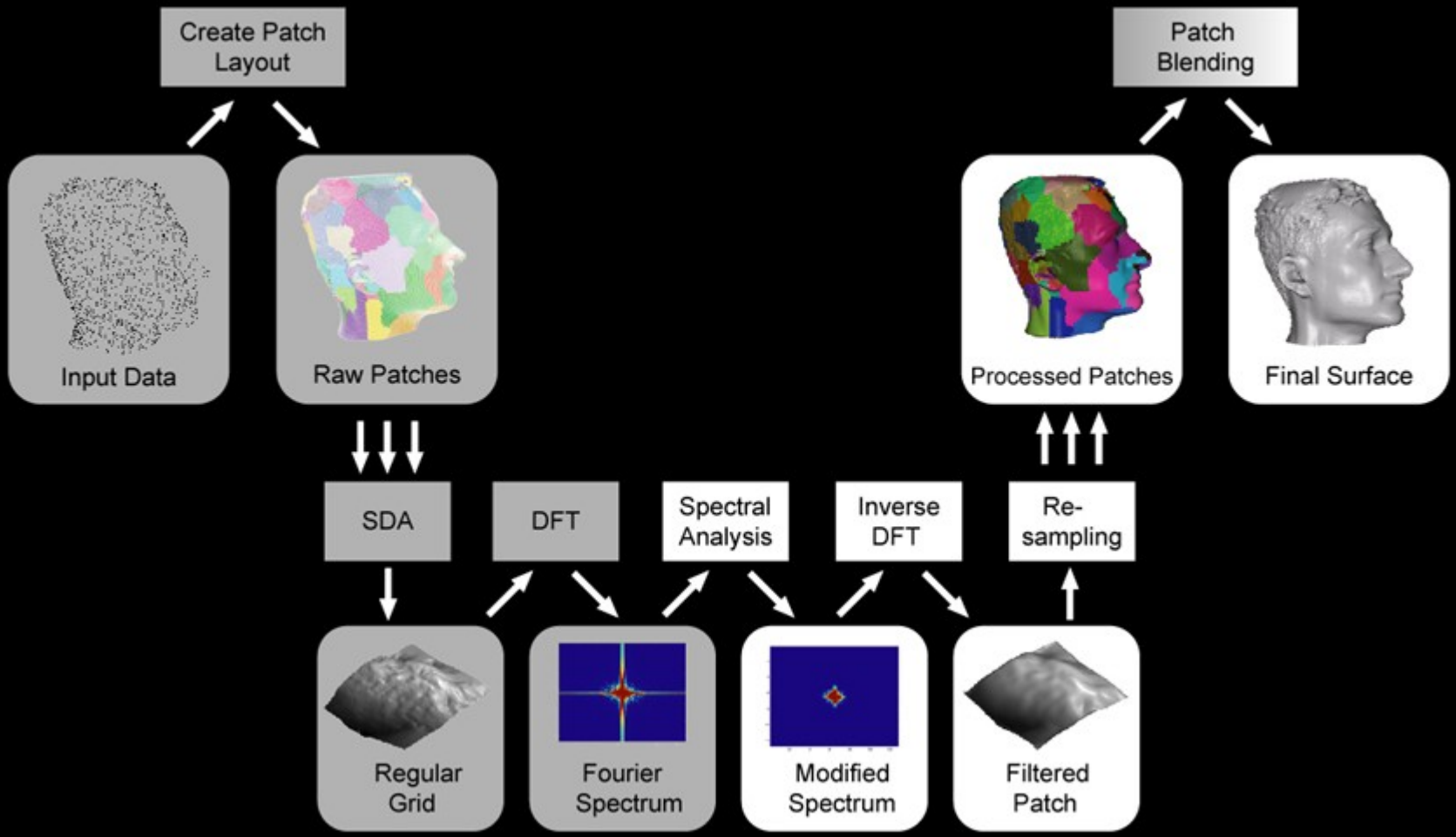
- Spectral filtering:
  - Noise removal
  - Microstructure analysis
  - Enhancement
- Adaptive resampling:
  - Complexity reduction
  - Continuous LOD

Fourier Transform



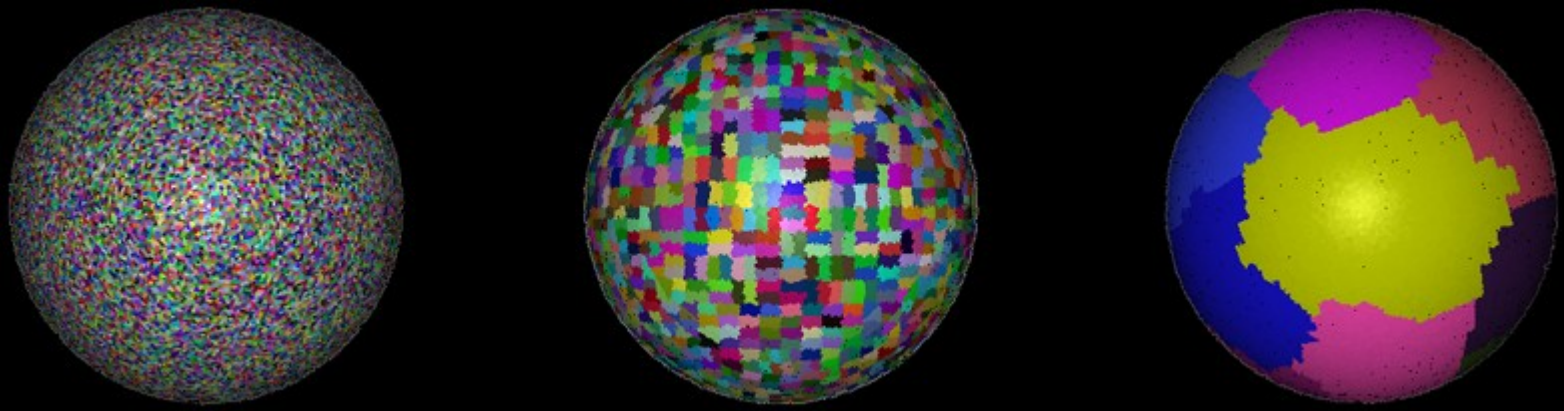
- Benefits:
  - Sound concept of frequency
  - Extensive theory
  - Fast algorithms
- Limitations:
  - Euclidean domain, global parameterization
  - Regular sampling
  - Lack of local control

Overview


Create Patch Layout
Patch Blending
Input Data
Raw Patches
Processed Patches
Final Surface
SDA
DFT
Spectral Analysis
Inverse DFT
Re-sampling
Regular Grid
Fourier Spectrum
Modified Spectrum
Filtered Patch

Patch Layout Generation

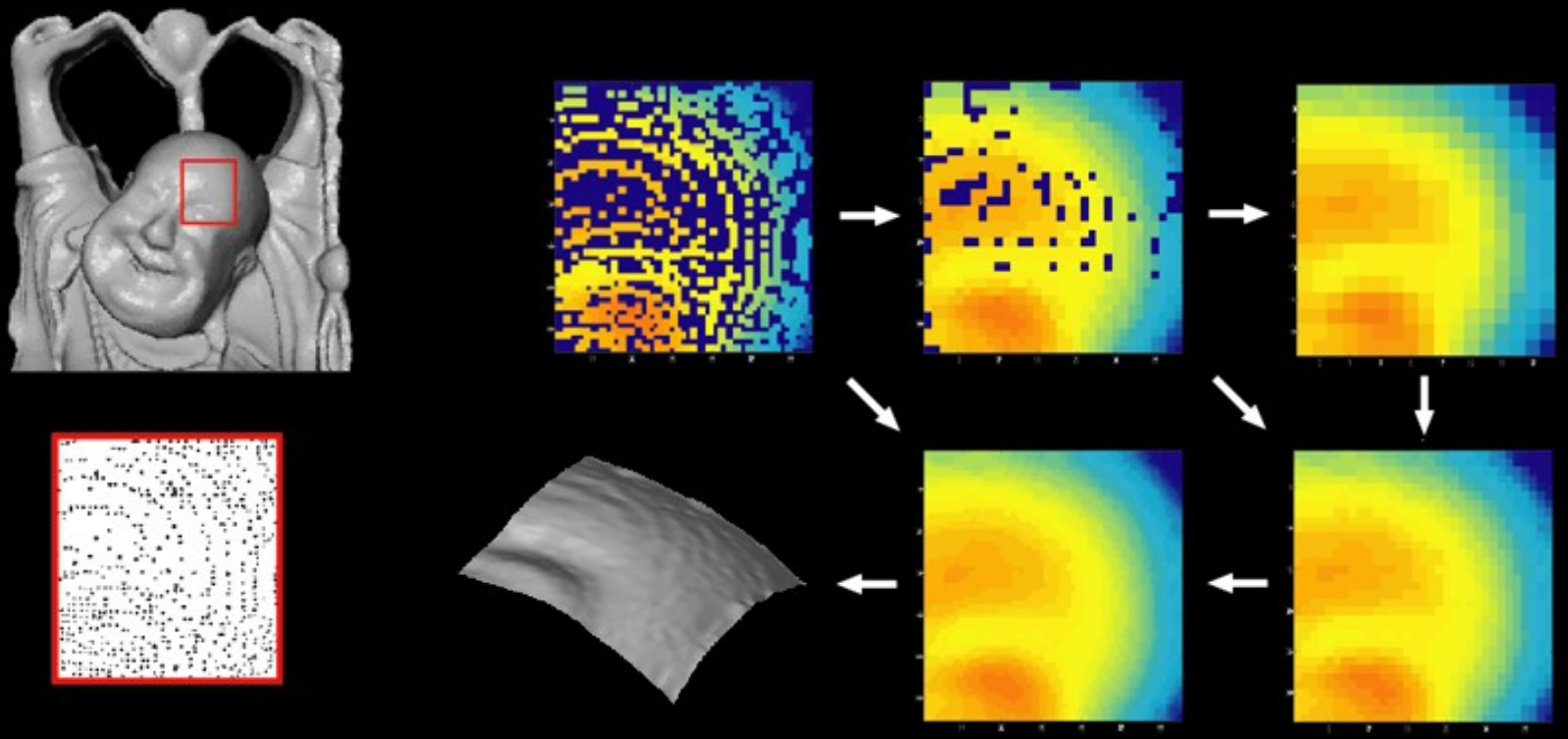
Clustering ⇨ Optimization



Samples ⇨ Clusters ⇨ Patches

Scattered Data Approximation

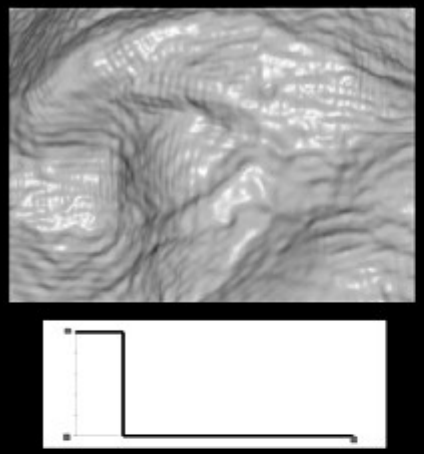
Hierarchical Push-Pull Filter:



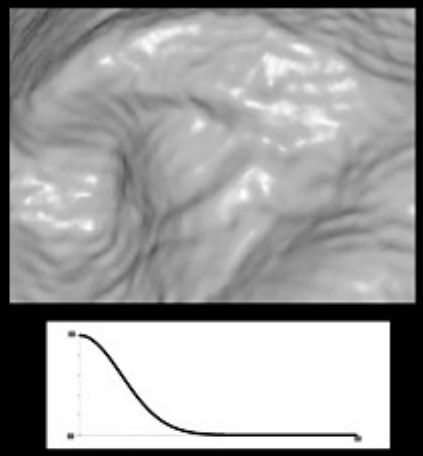
Spectral Analysis

- 2D Discrete Fourier Transform (DFT)
  - ⇨ Direct manipulation of spectral coefficients
- Filtering as convolution:
  - ⇨ Convolution: $O(N^2)$ ⇨ Multiplication: $O(N)$
- Inverse Fourier Transform
  - ⇨ Filtered patch surface

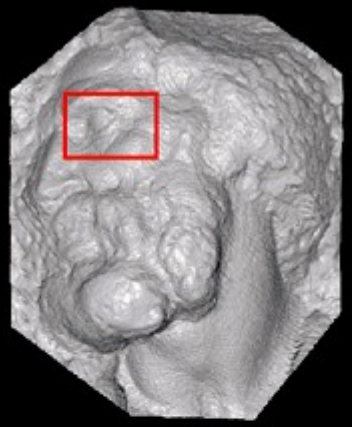
Spectral Analysis



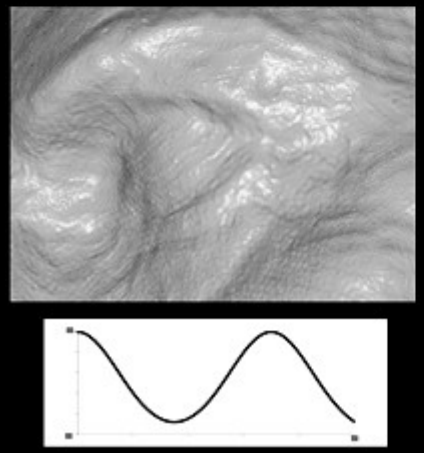
Ideal low-pass



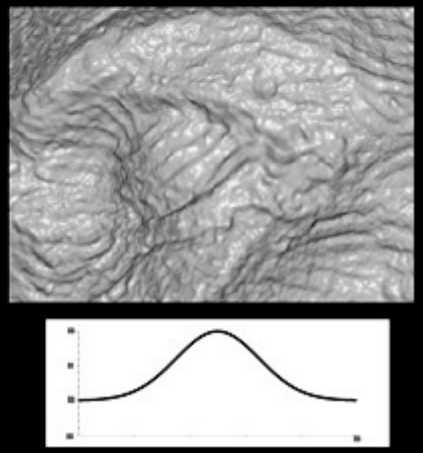
Gaussian low-pass



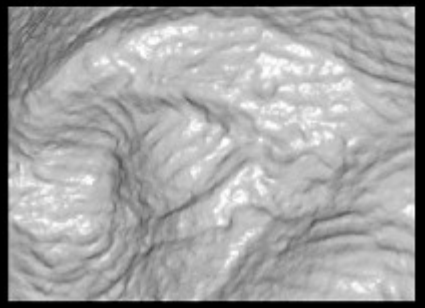
Original



Band-stop

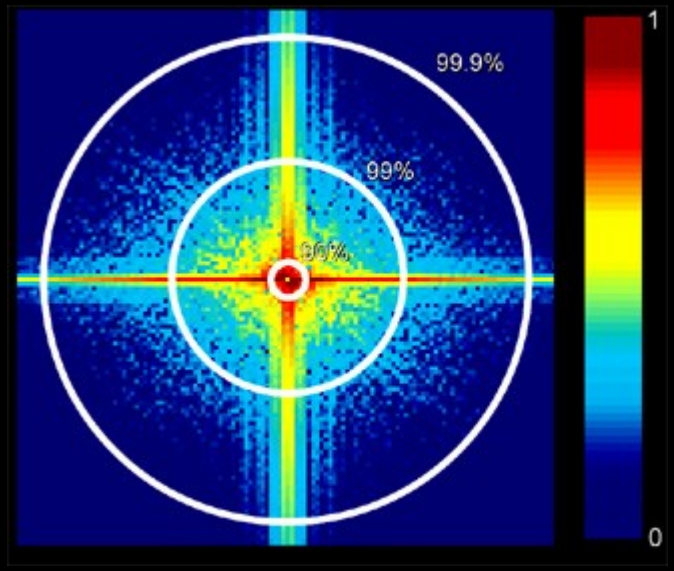


Enhancement



Resampling

- Low-pass filtering
  - ⇨ Band-limitation
- Regular Resampling
  - ⇨ Optimal sampling rate (Sampling Theorem)
  - ⇨ Error control (Parseval's Theorem)

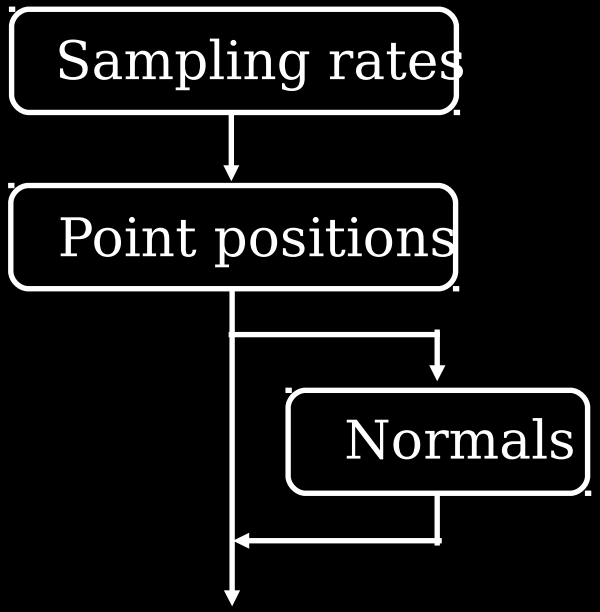


Power Spectrum

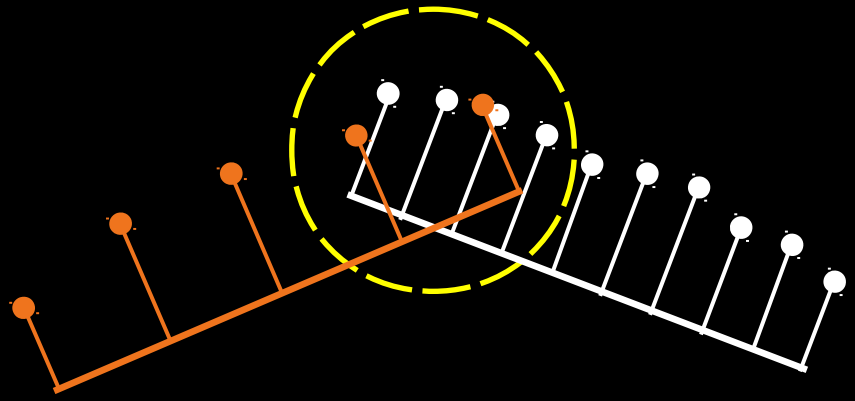
Reconstruction

- Filtering can lead to discontinuities at patch boundaries
  - ⇨ Create patch overlap, blend adjacent patches

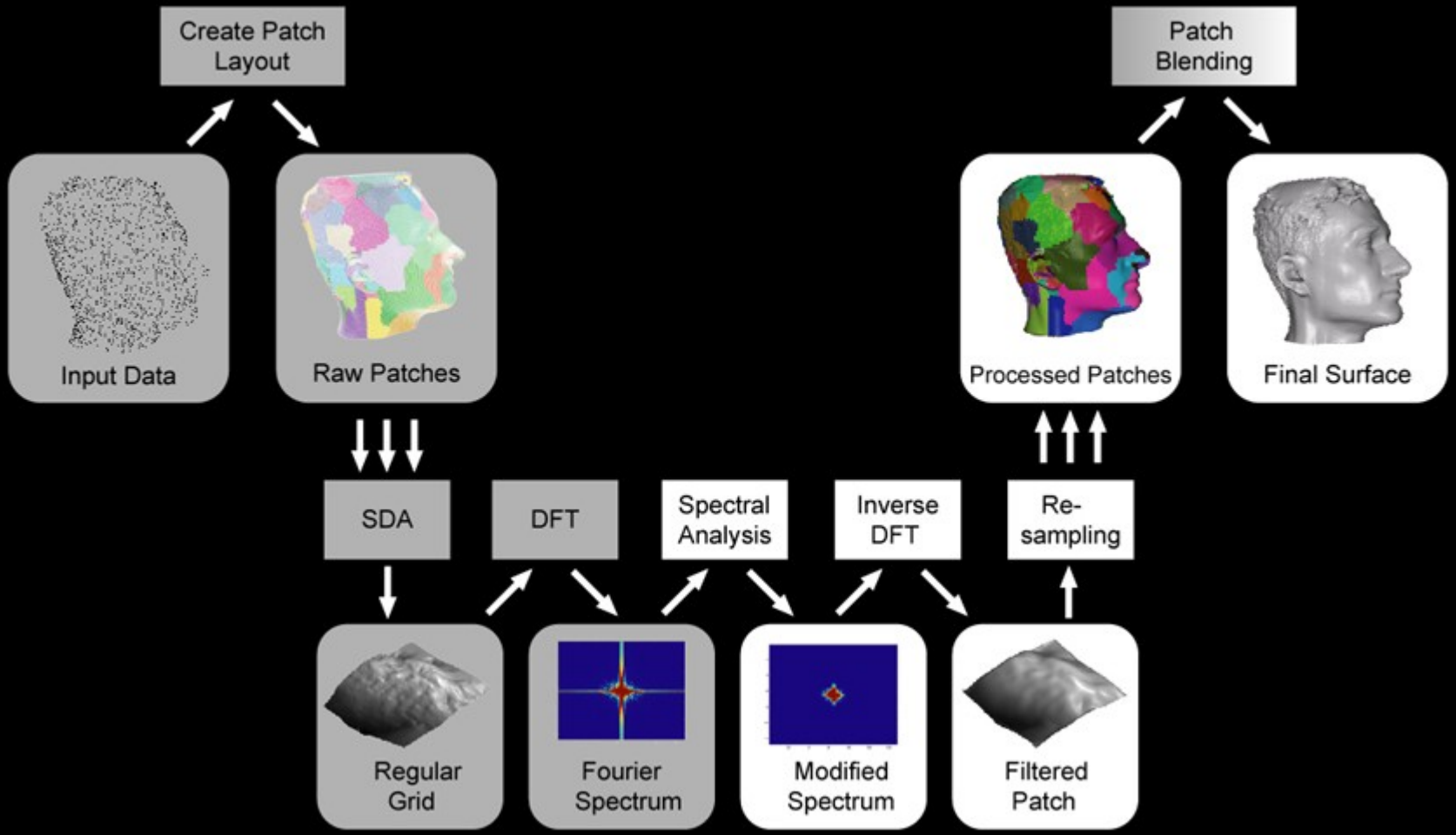
Blending:



region of overlap



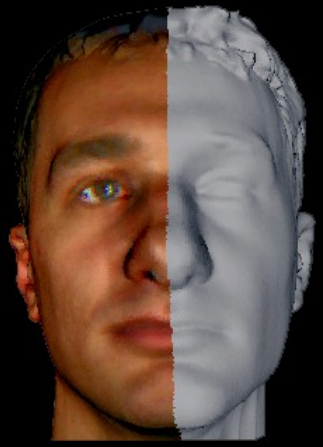
Spectral Processing Pipeline



Surface Restoration

Original

Gaussian



Wiener

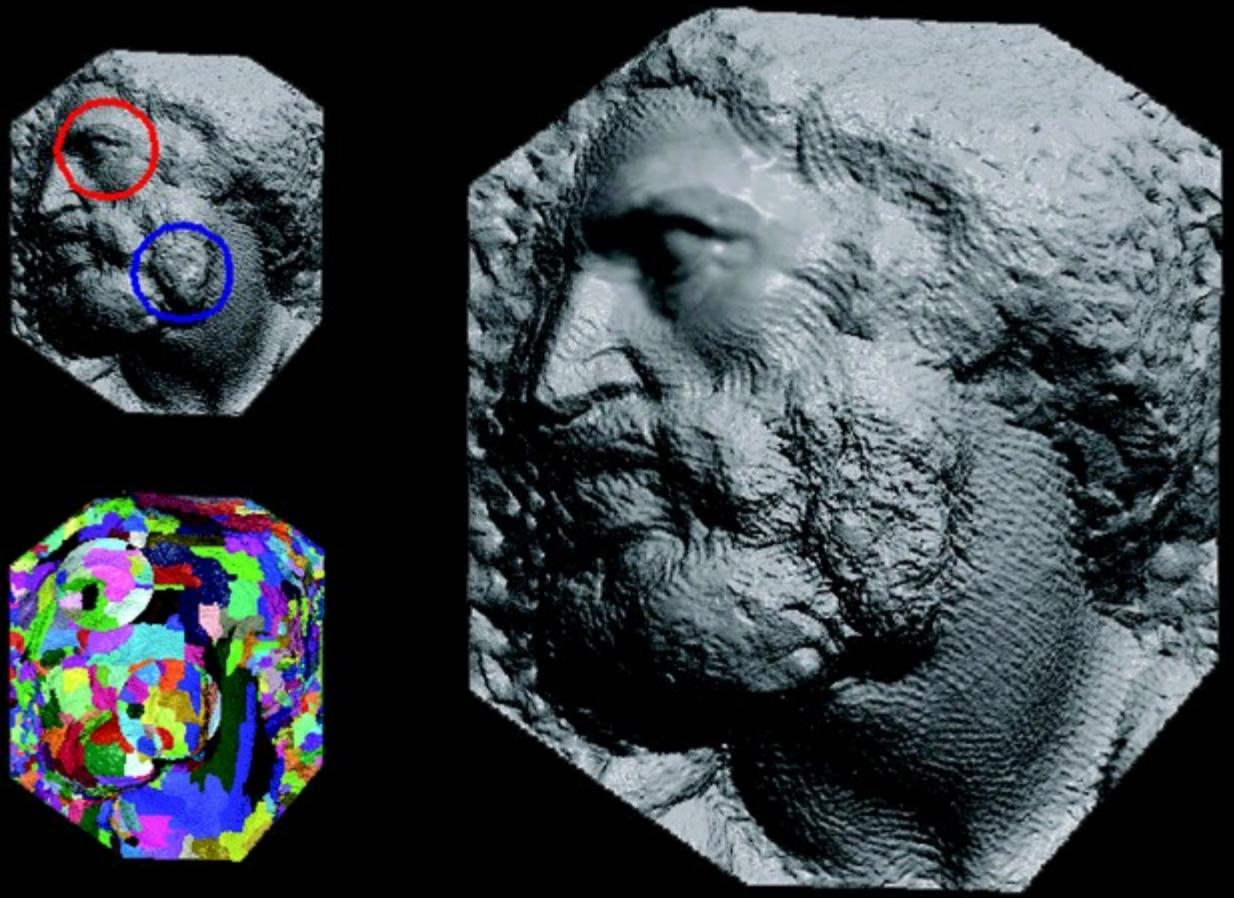
Patch

noise+blur

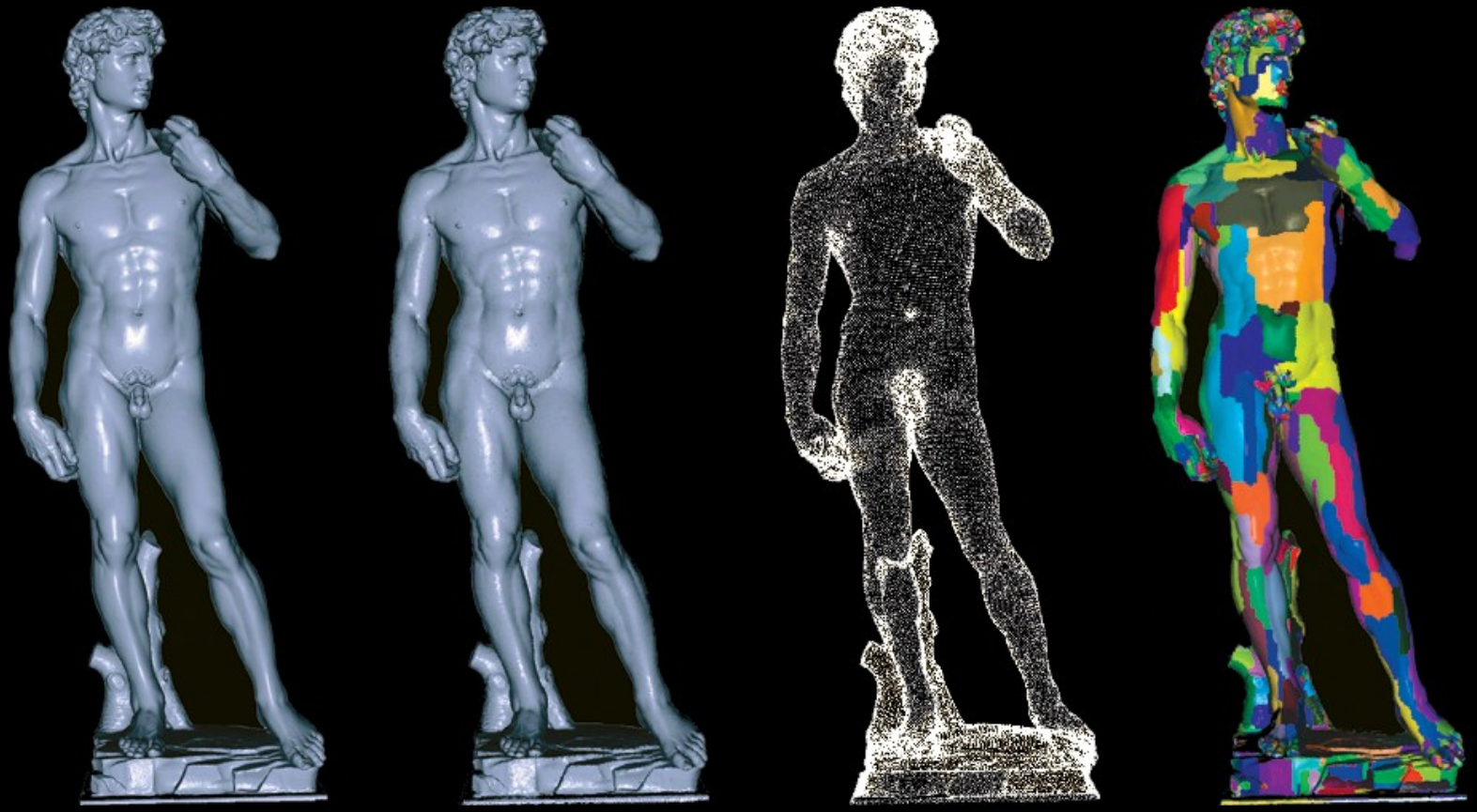
Filter

Filter

Interactive Filtering



Adaptive Subsampling

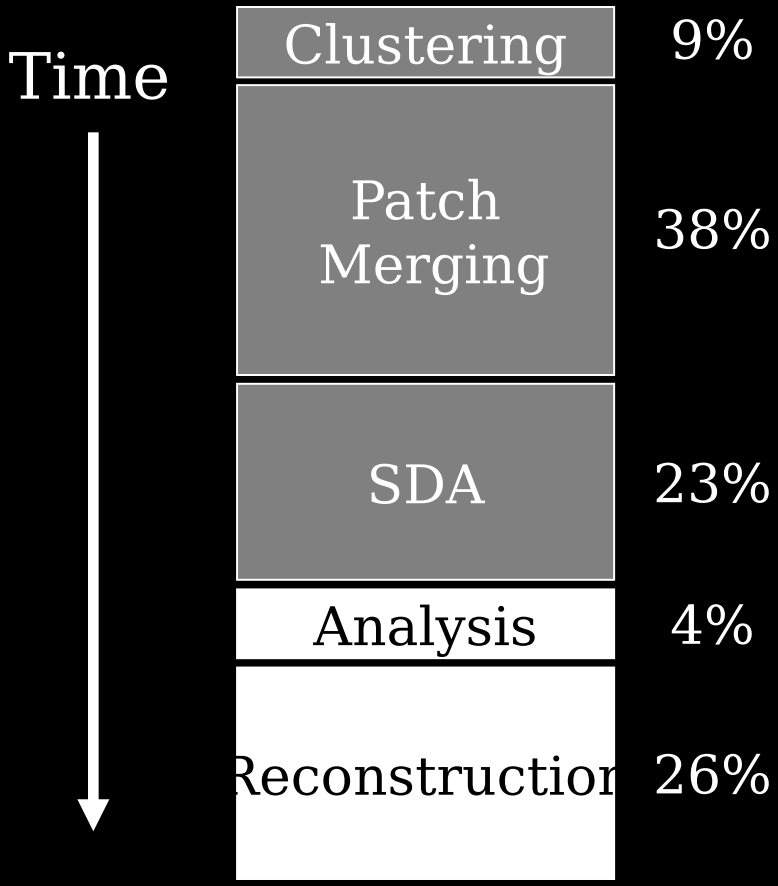


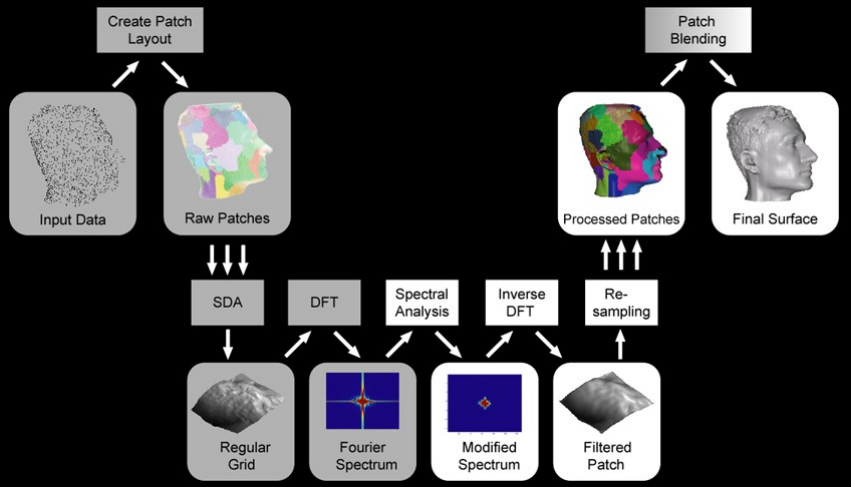
4,128,614 pts.
= 100%

287,163 pts.
= 6.9%

Timings

Time





Timings

			
#points #patches	460,800 256	3,382,866 595	4,[illegible],614 2,966
Preprocess	10.9	117.2	128.3
Total	15.8	153.0	189.6

Summary

- Versatile spectral decomposition of point-based models
- Effective filtering
- Adaptive resampling
- Efficient processing of large point-sampled models

Future Work

- Compression
  - Scalar Representation + Spectral Compression
- Hierarchical Representation
  - Modeling and Animation
- Feature Detection & Extraction
  - Robust Computation of Laplacian

Acknowledgements

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